Chemical Theory of Life

Chemical Theory of Life's Origin and Its Experimental Evidence

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Explore the chemical theory of life's origin on Earth, supported by Miller-Urey experiments and abiogenesis hypotheses, in this detailed academic overview.

Introduction

How did life first emerge on Earth? This question has intrigued scientists for centuries and led to a variety of hypotheses. Among these, the chemical theory of the origin of life—also known as primary abiogenesis—offers one of the most compelling, evidence-based explanations.

It proposes that life began through a series of natural chemical processes in the unique conditions of the early Earth. The modern form of this theory was developed by scientists like Oparin and Haldane and later supported experimentally by Stanley Miller and Harold Urey.

This theory not only explores how simple inorganic compounds evolved into complex biomolecules but also delves into the gradual formation of protocells and, ultimately, living cells. Understanding this process is essential for students, researchers, and anyone interested in evolutionary biology or astrobiology.

In this article, we'll look at a verbatim excerpt from a Zoology thesis explaining the stages of chemical evolution, accompanied by the landmark experiments that brought this theory to life. The focus keyword, **chemical theory of life**, reflects the central theme explored in detail below.

Article

Chemical Theory: The Modern Explanation of Life's Origins

"6. Modern Theory: The modern theory is also known as 'CHEMICAL THEORY' or THEORY OF PRIMARY ABIOGENESIS. In the modern theory, the hypothesis of abiogenesis was proposed with a condition that the non-living materials can give rise to life in the condition of primitive earth.

The condition of the primitive earth is different from the present conditions which donot permit abiogenesis. The idea of chemical theory was put forward by two scientist, A.I. Oparin and J.B.S Haldane. It has made following assumptions:

1. *Spontaneous generation of life under the present environment is not possible.*
2. *Earth's atmosphere ~1 billion years is very different from the current conditions.*
3. *Primitive earth's atmosphere was reducing in nature.*
4. *Under these conditions, the chemical molecules (inorganic molecules) react with each other through a series of reactions to form organic substances and other complex biomolecules.*
5. *The solar energy and UV radiation provided the energy for the chemical reactions.*

Experimental Evidences Supporting Chemical Theory

The hypothesis proposed by Haldane dentation. To conclusively support the chemical theory, Miller and Urey conducted experiment in mimicking primitive earth environment. The experimental design used for the experiment is given in the Figure3.1.

The experimental setup consists of a glass flask, a condenser, and a liquid flask interconnected with tubes and a source of electric spark to provide energy (Figure3.1). He introduced a mixture of methane (CH4), ammonia (NH3), and hydrogen (H2) in the ratio of 2:2:1 and water (H2O) vapor at 80000C.

He allowed to circulate the mixture into this closed glass apparatus for 18 days continuously. He provided energy in the form of spark by supplying electricity of 75000 Volts through two electrodes. The electric sparks mimicks lighting in the primitive earth atmosphere. While passing the mixture, gases were passes through a liquid flask to simulate the volcano.

The mixture was collected from the stop cock and analyzed using chromatographic and calorimetric techniques. The analysis of mixture indicates the presence of amino acids such as glycine, alanine, aspartic acid, nitrogen base adenine and simple sugar ribose.

In addition, he found hydrogen cynide (HCN), formaldehyde (HCHO) and other active intermediate compounds such as acetylene and cyanoacetylene.

Steps Proposed In The Origin Of Life

According to the chemical theory of origin of life, a series of chemical synthesis give rise to life. As per the hypothesis, origin of life have four major steps:

(1) Formation of Inorganic Molecules: The high temperature of primitive earth didn't allow the condensation of atoms to form inorganic molecules. As temperature of earth goes down, condensation of different atoms give rise to simpler molecules.

The elements most abundant on the primitive earth are hydrogen, oxygen, nitrogen and carbon. The reaction of these molecules give rise to the

different gases such as hydrogen, nitrogen, ammonia, methane, carbon dioxide and water vapor.

The energy for these reactions was provided by sunlight, lighting or volcanic eruptions.

(2) Spontaneous Formation Of Monomeric Organic Compounds: The simple molecules interact with each to form simple monomeric organic compounds. These molecules were sugar, fatty acids, glycerol, amino acids and organic bases (purine/pyrimidine).

The reactions between the inorganic to give simple organic molecules occurs in reducing environment inside ocean. The inorganic molecules were condensed in the form of rain as temperature of earth lower down.

Hence, both inorganic compounds and simple organic compounds were present in the primordial ocean.

(3) Spontaneous Formation Of Complex Organic Compounds: The small, simpler organic compounds react to form complex organic compounds. The simple amino acids reacts to form polypeptides, sugar reacts to form large sugar molecules, fatty acid and glycerol combined together to give fat. Heat of the sun is utilized for providing energy for these reactions.

(4) Spontaneous Formation Of Molecular Aggregates: large organic molecules came together to form large colloidal aggregates called as coacervates. A layer of water molecules forms around the protein molecules present in coacervates. The membrane present around the molecules protect the molecule and bring high local concentration to enhance the chemical reactions.

The colloidal aggregates absorb protein and other molecules from the ocean. This results in growth in coacervate as well as internal complexicity. As coacervate divides into multiple small ones.

These coacervates are the initial species present in the ocean to start the formation of primary cells. This process is accomplished in two steps:

(i) Formation of Eobionts Or Protocells: The coacervates has the ability to

take up new molecules to replace the degraded molecules and maintain the size. Thus, coacervates has the basic property of living system but it doesn't have complex molecules such as enzyme etc.

The process of acquiring new molecules was not regulated. Later, nucleic acid is entrapped within the coacervates and process of division became precise and controlled. This form of coacervates with nucleic acid is known as eobionts or protocells.

(ii) Formation of First Cells: Protein molecules and appearance of enzymes has enahced the synthesis of several of biomolecules in eobionts. RNA and DNA developed and these molecules has taken over the protein synthesis.

Interaction of lipid and protein allowed the formation of biomembrane which has provided selectivity in the primitive cell for intake or exclusion of material. It allowed the appearance of membrane bound protocell and that has eventually given first cell on earth.

The mutation in DNA and selection of fast growing cell give rise to the appearance of first primordial cell. The first cellular form on earth appeared ~2000 million years ago."

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